Spanish National GPS Reference Stations Network (ERGPS).

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1. INTRODUCTION

The Instituto Geográfico Nacional de España, through its geodesy department, since 1997 has carried out the establishment of a GPS Reference Station Network (ERGPS) delivered all around Spain which allows millimetric co-ordinate results, as well as velocity fields in a Global Reference System (ITRFxx). It serves as support for the other geodetic networks and for technical and scientific works. Some of these stations are being integrated into the EUREF (EUropean REference Frame) Permanent Station Network. The ERGPS forms the zero order of the Spanish new geodesy.

2. OBJECTIVES

The basic objectives for the ERGPS network are:

- To obtain more precise co-ordinates and velocity fields in all parts of the network, with the aim of constituting the zero order of Spanish geodesy.
- To contribute to the definition of the new Global Reference Systems (ITRFxx) in Spanish territory.
- To publicly provide to GPS users, both national and foreign, data for cartographic, topographic, and geodetic work, and for general positioning.
- To primarily use the data registers for geodynamic ends, but also in other projects where continuous data registry is necessary: studies at sea level, studies of the ionosphere, the troposphere, etc.
- To contribute to the permanent station European Network EUREF, and thereby to the support of the European Reference Frame.
- To serve as support for the national DGPS service.

3. SPANISH NATIONAL GPS REFERENCE STATIONS NETWORK (ERGPS)

The Instituto Geográfico Nacional, aware of the importance of establishing a network of Permanent GPS Stations that systematically cover Spanish territory, in 1997 began to propose a project creating a network of permanent GPS stations, by laying out the objectives and equipment needs. A first phase of tests was initiated, the first of these stations being installed at a key point for the Spanish national Datum, such as the Port of Alicante Tide Gauge Subnetwork, the origin of the mean sea level adopted as zero reference for Spanish cartography.

It was in March of 1998 when it was ultimately installed, and consisted of continuous tested data registers from April of that same year. It has been considered operative since that time. In 1999 it was completely integrated in the EUREF (ALAC) network.

That same year, 1998, the second of the stations, in the tide gauge of the Port of A Coruna was installed, with continuous data from January of 1999. It was integrated in EUREF in September of that year with the code ACOR.

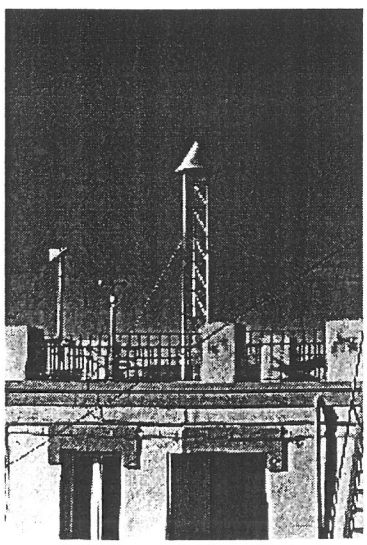

Fig. 1.- ERGPS Almería (ALME).).

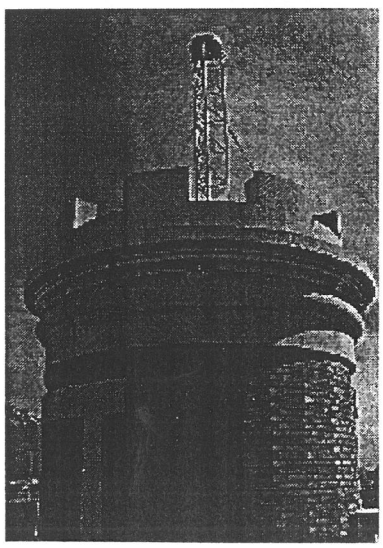

Figura 2.- ERGPS de Alicante (ALAC).

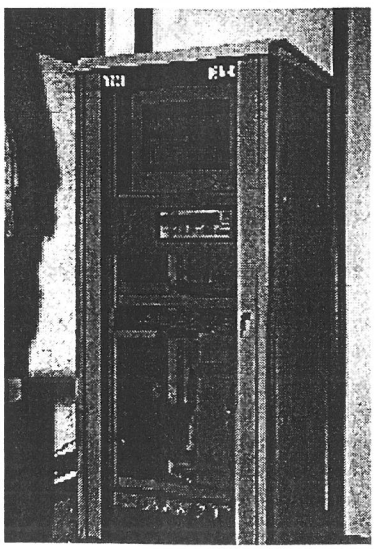

Figura 3.- ERGPS de Yebes (YEBE).

In 1999 the permanent GPS station of the Yebes Astronomical Observatory (YEBE) was installed. Here, with the 14 meters radiotelescope of the Observatory (CDP 7333), regular VLBI (Very Long Baseline Interferometry) high precision observations have been made within the CORE and EUROP programs. The GPS receiver uses the Hydrogen Maser frequency standard also available in the observatory, besides the continuous registry of temperature and atmospheric pressure.

The determination of the local tie between Yebes GPS permanent station and the radiotelescope reference point, performed periodically through high precision geodetic observations, will make possible the joint use of the results of the VLBI of the radiotelescope and the results of the GPS data from the permanent station. The idea is that, in the future, this station might become the kernel of the ERGPS network.

station of the University of Valencia (VALE) were installed, the latter in December of 1999.

Three other stations were installed early in the year 2000: at the University of Santander (CANT) in March, in the Geophysical Observatory of Malaga (MALA) in April, and in the Oceanographic Institute of Palma de Mallorca (MALL) in May, comprising a total of eight stations.

The installation of stations will continue throughout the year, with stations expected in Logroño, Cáceres, Ceuta, Zaragoza, León, San Pablo de los Montes and La Palma. The network of operative stations is expected to be completed by the end of next year.

4. INSTALLATION AND MARKING

In the definition of the sites of the permanent stations, the IGN has taken into account the stations of other

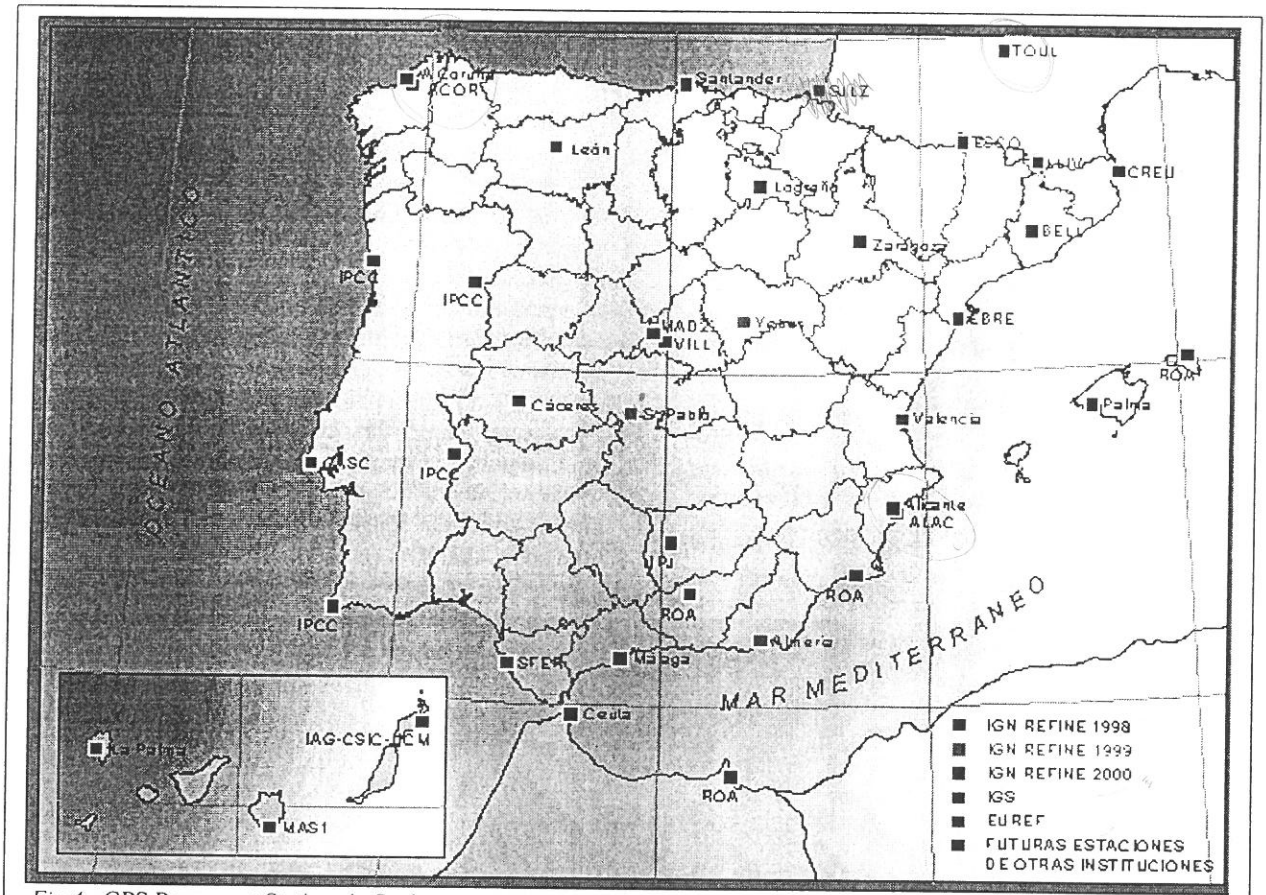

Fig 4.- GPS Permanent Stations in Spain.

Also in 1999, the construction of a new radiotelescope, 40 meters in diameter, was begun. In the future it will replace the present 14 meter radiotelescope in the observation programs that the observatory is involved in.

Following this, the stations of the Geophysical Observatory of Almeria (ALME) and the permanent

already operating bodies within Spanish territory: San Fernando in Cádiz (ROA), Villafranca in Madrid (ESA), Robledo in Madrid (NASA) and 5 stations in Catalonia (ICC). Moreover, the IGN follows a joint strategy with the Instituto Português de Cartografia e Cadastro and the Real Observatorio de la Armada and the future development plans for permanent stations of both institutions.

The stations are chosen such that the maximum separation between them is 250 kms and, in the case of coastal stations, the criterion is that the distance from the main tide gauge not be greater than 10 kms. The site is chosen to guarantee stability, durability, and maintenance as long as the station is operative.

The site where the stations are installed must be a closed building with the necessary supply of electricity and telephone access to transmit data by modem. In some of them Internet access is also available. The horizon must always be unobstructed above 10 degrees.

The receptors used up to now receive L1 and L2 carrier phases completely, as well as their respective C/A and P codes. They incorporate the capacity to generate RTCM and RTK code and some system of interference elimination. The antennas that include Dorne-Margolin elements and a choke ring are appropriately oriented. They are protected from the snow and other meteorological elements, and the incursion of birds in coastal zones, by antenna covers.

Before installing a permanent station, the structure beneath must be tested for complete geological stability. Similarly, the absence of significant radioelectric emissions which could

distort the signal, especially L2, should be confirmed, as well as a clear GPS horizon.

The marking system has been developed by the Geodetic Programs Service of IGN and has already been used in some of the signal codes of the EUVN campaign. It consists of markers with altimetric references furnished with high precision levelling on a concrete base. When an obstacle requires it, on the same base a tower

should be constructed in order to raise the antenna in a perfectly vertical fashion to clear the obstacles. Distortions caused by changes in temperature and wind velocity will be controlled for.

The equipment should be completed with current stabiliser or UPS unit, supplementary batteries in case of a power outage, a PC to manage and maintain the receiver as well as store and transmit the data generated. A modem for data transfer (via Internet or telephone) and other accessory elements are also necessary.

5. DATA FLOW

The archives generated by the ERGPS are stored daily and are automatically transmitted to the Central Services of the IGN in Madrid by Internet, preferably, or by regular telephone line. Both options are available in the stations. In the future the transmission is expected to be by VSAT Satellite.

The generation of data follows the IGS/EUREF standards for this type of product. A track with 30 seconds sampling rate with 24 hours files is performed. A second track of 1 hour files is performed in some of the stations.

The IGN processes the raw data, transforms them to a universal format (RINEX), then checks for quality (QC Quality Check), compacts with a Hatanaka algorithm and prepares the corresponding subproducts for public distribution and also for the Institute itself, within its own phase of analysis.

The data are also automatically sent by Internet to the Regional Data Centre EUREF BKG in the case of the EUREF integrated stations. They are made available to the public and are processed for the EUREF analysis centres. The data are also automatically distributed to other institutions that collaborate in scientific or research projects.

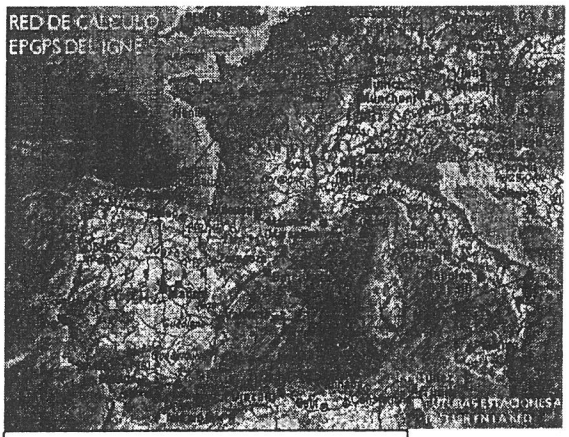

Fig 5.- Procesing strategy at IGN(E).

These data will soon be available in a data base accessible from a web page belonging to the Geodetic Area of IGN, as well as other products.

6. DATA ANALYSIS IN IGN

In the final phase of the process, the Geodetic Area has also begun to process data from its permanent stations and to calculate a daily solution. The final objective is for the IGN to become a Local Analysis Centre, by furnishing an Iberian subnetwork solution to EUREF.

Presently the data is being automatically processed with Bernese 4.2, by its Bernese Processing Engine (BPE) from the University of Bern, with very

satisfactory results. Analysis parameters consists on data resampling with intervals of 180 seconds in spite of the fact that the data are taken every 30 seconds, tropospheric parameter estimates every two hours and ambiguity resolution with Quasy Ionosphere Free (QIF), obtaining daily and weekly solutions by combining and resolving the normal equations.

Although a "free network" solution is first performed, the IGN presently is processing an Iberian network for its own analysis with a constrained solution for three significant stations of IGS: Villafranca (Madrid), Wettzell (Alemania) and Matera (Italia).

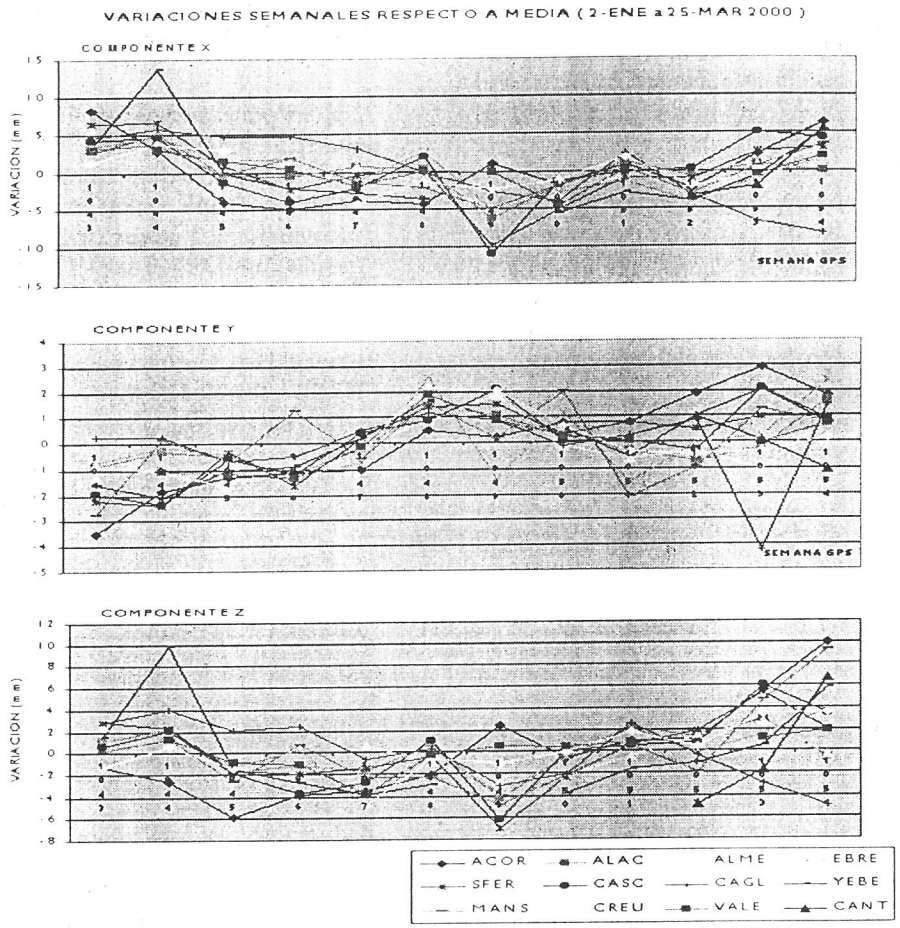

Fig 6.- Coordinate series jan- feb- mar 2000.